RESEARCH CIRCULAR 229 APRIL 1977

TURKEYS: A SUMMARY OF RESEARCH--1977

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
U. S. 250 and Ohio 83 South
Wooster, Ohio

CONTENTS

*** * ***

AGDEX 453/11-14-15-31-35 663

4-77-3M

The Effects of Intermittent Light or the Presence of Toms on Reproductive Performance of Hen Turkeys

WAYNE L. BACON and KARL E. NESTOR[1]

INTRODUCTION

Egg production of turkey hens is controlled by the length of the light day. Usually, turkey hens are restricted to a day length of 6 to 8 hours for 6 to 8 weeks prior to exposure to stimulatory light of 14 or 16 hours per day at about 30 weeks of age. Current recommendations are for an intensity of 50 lux for heavy weight strains during the breeding season, while 20 lux may be adequate for medium weight strains.

In chickens, the effects of intermittent light (10 minutes every 4 hours) in comparison to 17 hours of light per day were recently reported by Bell and Moreng (2). No difference in egg production was found, while the intermittently lit group had slightly greater egg size and a 10% better feed conversion.

Intermittent light regimens in Coturnix quail gave equivalent egg production to 14L:10D when the equivalent light period of the intermittent light groups was 13 or more hours (1). The equivalent light period (ELP) is defined as the interval from the beginning of the first light period to the end of the last light period.

In turkey hens, Brown *et al.* (4) compared 14L: 10D to intermittent light of five periods of 1 hour of light at 51 lux every 3 hours interspaced with background light of four lux (ELP at 51 lux of 13 hours). No significant difference was noted for eggs per hen, number of clutches, eggs per clutch, or rate of lay. However, significantly more broody periods and longer broody periods were found for the intermittently lit group.

The main objective of the present series of experiments was to study the effects of intermittent and continuous light regimens on traits of economic importance in laying turkey hens of different strains. In addition, the possible effects of the presence of males in the laying house, changing from intermittent to continuous light, and slowly increasing the length of the light period as the production period progressed were also examined.

MATERIALS AND METHODS

The hens used in these studies were from four medium weight strains described in detail by Brown and Nestor (3). These four lines were those selected for increased egg production (E), high (H), and low (L) blood corticosterone levels after cold stress at 4 weeks of age, and the corresponding randombred control (RBC1). Seven heavy weight strains (6) were also studied. These seven strains were selected for increased 16-week body weight (F), increased average clutch length (C), decreased total days lost from broodiness (B), increased fertility (R), both increased egg production and 16-week body weight (I), and two sub-samples of a randombred control, RBC-2-1 and RBC-2-2.

All hens were reared in confinement until they were 8 weeks old. They were then transferred to ranges until 24 weeks old (September and October), when they were housed in floor pens in a windowless breeder house. The length of the light day was gradually reduced to 6 hours and then maintained at this length for 8 weeks prior to giving the stimulatory light regimen on Feb. 1 when the hens were 39 weeks old. Light intensity was maintained at 55 lux during the restricted and subsequent stimulatory periods (5).

Four stimulatory light treatments and one group exposed to males were compared. The first treatment was a standard 14 hours of continuous light (Treatment C). The second treatment (Treatment I) was an intermittent program of 1 hour of light followed by 2¼ hours of darkness repeated four times and then 1 hour of light followed by 10 hours of darkness (ELP = 14 hours). An attempt was made to do normal servicing of the birds in this treatment during the 1-hour light periods. However, on some occasions it was necessary for the caretakers to be present during the intermittent dark period. Very dim hall lights were used at this time.

Treatments C and I were repeated 3 consecutive years. Each year the treatments were moved to one of four different equal sized rooms, each containing 12 pens, within the house. In addition, during the first year a third treatment was tested. Light treatment C was combined with the presence of sexually mature male turkeys, placed in cages, in the same room of 12 pens as the females. The eight males were placed in two colony cages (four males in each cage). The male cages were elevated and centrally located so that the females could see and hear the males. This treatment is designated as C-M.

During the second year, a fourth treatment (I-C) was added. This treatment was the same as

[1]Associate Professors, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

the I treatment up to 56 days of production. Then the length of the four internal light periods was increased by 15 minutes every 14 days until 126 days of production, when it was 14 hours of continuous light, which was then maintained until termination of the experiment.

In the third year a fifth treatment (Treatment S) was added. This treatment was the same as Treatment C until 21 days of production. At this time the lighting period was increased 15 minutes every 14 days at either the beginning (first six increases) or the end of the lighting period. At 180 days of production, this treatment group was receiving 17 hours of light per day.

One hundred and eighty day egg production (beginning the day the first egg from all the hens was laid) was recorded. Average clutch length was obtained from the 180-day production data. A clutch is the number of eggs laid on consecutive days before skipping a day. A broody period is defined as 5 or more days with no egg(s) produced. Broody traits (number of broody periods and total days broody) were also based on 180 days of production. Reproduction traits were based on 84 days of production, beginning when the hens first reached 50% production.

Each hen was mated to a different male by artificial insemination using a paired mating system. Since a large number of males were used for each group of hens, the males used to inseminate the groups of hens in the various treatments should have had similar average fertilizing ability. Feed conversion data are available for the last 2 years only.

RESULTS AND DISCUSSION

Table 1 gives 84 and 180-day egg production records. The slight differences were not significant and therefore are considered due to chance. The small differences in average clutch length, which is a very sensitive indicator of intensity of lay, were also not significant and are attributed to chance.

Floor egg production was not taken into account in Table 1, but is presented in Table 2. The incidence of floor eggs was greatest under the treatments where egg production to 180 days was lowest. Thus, for total egg production at 180 days in large weight hens, Treatments I and C were the same (92.3 eggs per hen). In the medium weight hens, total egg production for 180 days was 93.5 for Treatment C and 89.4 for Treatment I. It is also apparent that most of the floor eggs were laid early in the production period, which probably reflects difficulties in training the hens to use the nests with the intermittent light regimen. The I-C treatment also had a greater incidence of floor eggs in both the large and medium weight strains. This difference was apparent early in the laying season (84 days) and was maintained, but did not increase in the later part of the production period.

Number of broody periods per hen and total days broody per hen are given in Table 3. A broody period was defined as any period of 5 or more days during which no eggs were laid. For the medium weight birds, Treatment S had fewer broody periods than Treatments C and C-M. The other slight differences were not significant and are therefore attributed to chance.

TABLE 1.—Egg Production Traits of Large and Medium Weight Hens Subjected to the Various Lighting Treatments.

Lighting Treatment*	No. of Birds	Egg Production to: 84 Days	180 Days	Average Clutch Length
		Large Weight		
C	190	51.1	90.0	2.25
I	192	50.0	88.5	2.13
C-M	69	51.2	93.3	2.30
I-C	57	52.9	90.7	2.21
S	65	49.5	92.8	2.18
P		0.56	0.58	0.11
		Medium Weight		
C	172	48.3	90.3	2.50
I	166	49.0	85.0	2.40
C-M	60	49.2	92.6	2.61
I-C	58	49.5	90.2	2.49
S	56	52.1	97.7	2.68
P		0.56	0.07	0.12

*C, 14 hr. light; I, intermittent light; C-M, 14 hr. light with presence of males; I-C, I changed to C starting at 8 weeks production; and S, increase of C by 15 minutes every 2 weeks.

TABLE 2.—Incidence of Floor Eggs in Large and Medium Weight Hens Subjected to Various Lighting Treatments.

Lighting Treatment*	No. of Birds	Floor Eggs per Bird to: 84 Days	180 Days
	Large Weight		
C	190	1.1	2.3
I	192	2.2	3.8
C-M	69	1.0	3.2
I-C	57	2.1	3.8
S	65	0.8	1.4
	Medium Weight		
C	172	1.3	3.2
I	166	2.6	4.4
C-M	60	1.5	3.7
I-C	58	1.9	3.5
S	56	1.7	3.0

*C, 14 hr. light; I, intermittent light; C-M, 14 hr. light with presence of males; I-C, I changed to C starting at 8 weeks production; and S, increase of C by 15 minutes every 2 weeks.

TABLE 3.—Broodiness Traits of Large and Medium Weight Hens Subjected to Various Lighting Treatments.

Lighting Treatment*	No. of Birds	No. of Broody Periods	Total Days Broody
	Large Weight		
C	190	2.41	36.4
I	192	2.54	35.6
C-M	69	2.11	38.6
I-C	57	2.21	36.2
S	65	2.36	29.6
P		0.52	0.77
	Medium Weight		
C	172	2.54	41.6
I	166	2.27	46.1
C-M	60	2.52	42.4
I-C	58	2.15	41.6
S	56	1.67	32.7
P		0.05	0.36
LSD .05		0.71	

*C, 14 hr. light; I, intermittent light; C-M, 14 hr. light with presence of males; I-C, I changed to C starting at 8 weeks production; and S, increase of C by 15 minutes every 2 weeks.

The reproduction data (fertility, hatchability, and number of poults per hen) are given in Table 4. No significant differences in reproductive performance are associated with light treatments or the presence of males. Also, egg weight and feed per egg were not affected by light treatment. For feed per egg, the comparison of I and C treatments indicated that the I treatment was 4% better for the large weight and 6% better for the medium weight hens. These differences were not significant, but are in agreement with Bell and Moreng (2), who worked with laying chicken hens and noted a 10% better feed conversion with an intermittent light regimen.

The difference in feed consumption between Treatments C and I was about 2.0 kg. per bird in both medium and heavy weight hens. At current feed prices in this region of about $0.12 per kg., this is a feed savings of $0.24 per bird during the laying season. If incandescent lights are used, at stocking densities of 0.6 and 0.8 m^2/hen (medium and heavy hens, respectively) and 100 W bulbs for each 10 m^2 of floor space (about 50 lux intensity), Treatment C would use either 7.56 or 10.08 kWh more electricity than Treatment I for medium weight and heavy weight hens, respectively. If 200 W bulbs are used, these figures would of course double. At $0.030 per kWh, this represents $0.23 to $0.30 per bird extra expense with Treatment C in comparison to Treatment I during a 20-week production period. If 200 W bulbs were used, these values would be $0.46 and $0.60. This savings in electricity and feed would amount to $0.70 and $0.84 less in production costs for each hen during the laying season, or approximately the value of two fertile eggs.

Re-examination of Table 1 at 120 days of production (17 weeks) shows equivalent egg production of both medium weight and heavy weight hens. Therefore, the intermittent lighting regimen used in this study may have potential field application, especially when feed and energy are relatively expensive.

TABLE 4.—Reproduction Traits of Large and Medium Weight Hens Subjected to Various Lighting Treatments.*

Lighting Treatment†	No. of Birds	Percent Fertility	Percent Hatch.	No. of Poults	Egg Wt. (g.)	Feed Conversion (g. Feed/Egg)
			Large Weight			
C	190	90.4	79.5	35.2	90.9	320
I	192	86.0	80.0	33.6	90.1	302
C-M	69	91.7	81.4	36.2	90.4	n. a.‡
I-C	57	83.4	80.6	36.5	89.3	316
S	65	87.7	79.3	34.1	91.2	310
P		0.15	0.90	0.54	0.57	>0.05
			Medium Weight			
C	172	83.8	82.6	34.5	84.4	230
I	166	83.1	82.1	33.6	84.7	220
C-M	60	83.0	78.7	32.3	85.3	n. a.
I-C	58	84.8	82.9	34.4	85.2	221
S	56	87.6	82.0	37.4	85.6	214
P		0.66	0.50	0.56	0.51	>0.05

*Data based on first 5 days of production after 50% of the hens were in production.
†C, 14 hr. light; I, intermittent light; C-M, 14 hr. light with presence of males; I-C, I changed to C starting at 8 weeks production; and S, increase of C by 15 minutes every 2 weeks.
‡Not available.

SUMMARY

Turkey hens were exposed to lighting regimens of 14 hours per day (C) or five intermittent 1-hour light periods spaced equally during 14 hours per day (I). Egg production at 84 and 180 days of lay and average clutch length were not affected by lighting treatment. Hens in regimen I laid about one more floor egg per hen than those in regimen C, and were more difficult to nest train. Number of broody periods and total days broody were not affected by lighting regimen in either medium or heavy weight hens. Fertility, hatchability, and number of poults per hen were also not affected. Feed per egg was not significantly different, but was in favor of regimen I. Estimated savings in production costs in favor of regimen I were equal to two fertile eggs.

Data are also reported for the above traits concerning regimen C with the presence of sexually mature males in cages within the pens, regimen I with a gradual change to regimen C starting at 56 days production, and regimen C with an increase in the light period of 15 minutes every 2 weeks. These three regimens were studied for only 1 year each. The results are thus preliminary in nature, but indicate responses to all the traits not greatly different from regimen C.

LITERATURE CITED

1. Bacon, W. L. and K. E. Nestor. 1975. Reproductive Response to Intermittent Light Regimens of Coturnix Quail. Poultry Sci., 54: 1918-1926.
2. Bell, D. D. and R. E. Moreng. 1973. Intermittent Feeding and Lighting of Leghorn Hens. Poultry Sci., 52: 982-991.
3. Brown, K. I. and K. E. Nestor. 1974. Implications of Selection for High and Low Adrenal Response to Stress. Poultry Sci., 53: 1297-1306.
4. Brown, K. I., K. E. Nestor, W. L. Bacon, and S. P. Touchburn. 1973. Effects of Intermittent or Continuous Lighting and Light Intensity on Reproductive Performance of the Turkey and Japanese Quail. Proc., 4th Europ. Poultry Cong., London, pp. 79-84.
5. Nestor, K. E. and K. I. Brown. 1972. Light Intensity and Reproduction of Turkey Hens. Poultry Sci., 51: 117-121.
6. Nestor, K. E., P. A. Renner, and K. I. Brown. 1973. Heritability of Viability During the Early Growing Period of Turkeys. Poultry Sci., 52: 2260-2266.

The Influence of Two Methods of Artificial Insemination on Turkey Fertility

KARL E. NESTOR, PHILIP A. RENNER, and KEITH I. BROWN[1]

INTRODUCTION

Fertility of artificially inseminated turkeys usually declines as the reproductive period advances (1, 8, and others). The decline in fertility may be the result of a similar decline in semen quality as the age of the male increases (2, 9), physiological changes occurring in the female during the laying period (5), faulty insemination techniques (7), mechanical spread of infectious agents from hen to hen by the insemination technique, or a combination of these.

Most turkey breeders and hatching egg producers are now using a disposable plastic tube for insemination in order to prevent spread of vaginal infection. Nestor and Brown (6) compared the use of the insemination tube with use of a glass rod and syringe and found higher fertility with the insemination tube. The use of a common tube for all hens or a clean tube for each hen gave similar fertility, suggesting that prevention of spread of infectious organisms was not a factor in the superiority of the tube method.

There has been a considerable amount of controversy recently concerning the proper depth of insemination. Wentworth *et al.* (10) observed that hens inseminated shallow (2 centimeters in vagina) had greater fertility than those inseminated deep (7 centimeters). On the other hand, Holleman and Biellier (3) found the opposite was true. In another study (4), the latter workers found that fertility was higher if the pressure used to evert the oviduct during insemination was released prior to depositing the semen rather than after depositing the semen.

The purpose of this study was to compare two methods of insemination which differed in depth of depositing the semen in the vagina and differed in control over the timing of release of pressure applied to evert the oviduct and deposition of the semen.

MATERIALS AND METHODS

A sample of four medium weight and six large bodied strains was assigned to each insemination method. The hens were inseminated twice weekly beginning with the production of the first egg and then biweekly inseminations were used during a 12-week hatching period. The amount of semen inseminated per hen varied from hen to hen but was usually greater than that generally recommended (0.025 cc./hen).

Method A consisted of placing the females between the "breaker's" legs with the back up and everting the oviduct with both lateral pressure and pressure by forcing back the tail head. A second person inserted the insemination tube into the oviduct as far as it would go without resistance, and as soon as the pressure was released, blew the semen into the oviduct by the use of a plastic hose attached to the insemination tube. The hen was then dropped to the floor.

Method B consisted of a catcher placing the hen on the lap of the inseminator who was sitting down. The hen's head was facing away from the inseminator and the breast rested on both legs of the inseminator. The inseminator rolled out the oviduct by putting pressure on the tail head and then inseminated the semen as in method A after the pressure was released. After insemination, the hen was allowed to slide to the floor. This method has the advantage that the inseminator is also the breaker so that better coordination between the release of pressure and insemination could possibly be achieved. Also, it was believed that the semen might be placed deeper in the oviduct with method B, although no measurements were made. The same person did the inseminations with both methods.

RESULTS AND DISCUSSION

There were no significant differences in percent fertility, percent hatchability of fertile eggs, or the number of poults produced per hen during the 12-week hatching period due to insemination methods

TABLE 1.—The Effects of Two Different Methods of Insemination on Reproduction of Medium Weight and Large Bodied Turkeys.

Method of Insemination	180-Day Egg Production (No./Hen)	Percent Fertility*	Percent Hatch. Fertile Eggs*	Poults Produced per Hen (No.)*
Medium Bodied				
Method A	90	86	84	35
Method B	94	85	84	37
Large Bodied				
Method A	88	85	80	34
Method B	94	83	84	36

*Based on a 12-week hatching period begining when the hens first achieved approximately 50% production.

[1]Associate Professor, Instructor, and Professor and Associate Chairman, respectively, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

(Table 1). There were no significant interactions between strains within weight types and insemination methods so the data are presented according to weight classification. There were 100 medium weight and 115 heavy weight hens given treatment A. The corresponding numbers of hens for treatment B were 69 and 86, respectively.

Although there were no significant differences, the hens inseminated by the use of method B had four and six more eggs per hen for medium and large bodied strains, respectively, during an 180-day production period (Table 1). This was surprising for one of the apparent features of method B was the struggling of the hens which was not evident in method A. In fact, the inseminator was forced to wear baseball shin guards to protect his legs from injury with method B. However, based on egg production data, this apparently did not harm the hens.

The lack of a difference in fertility between insemination methods could be the result of several factors. Among these are: 1) the depth of insemination in method A was adequate for maximum fertility, 2) inseminating an excess of sperm masks effects of depth of insemination, or 3) the depth of insemination was not important after a certain point was reached. One problem with recommending a specific depth to place the sperm in the oviduct is the variance in length of the oviducts in different hens. If insemination depth is constant and deep, the insemination tube may go through the oviduct and the semen would be deposited in the body cavity, resulting in loss in fertility and perhaps reduction in egg production. Therefore, it is probably important to only insert the insemination tube as far into the vagina as it will go without resistance.

SUMMARY

Two methods of inseminating turkey females were compared. One method consisted of "breaking" the female between the legs of the inseminator; with the other method, the vagina of the female was everted while the female was resting on the knees of the inseminator. There were no significant differences in fertility between insemination methods with either method of insemination.

LITERATURE CITED

1. Hale, E. B. 1955. Duration of Fertility and Hatchability Following Natural Matings in Turkeys. Poultry Sci., 34: 228-233.
2. Harper, J. A. and G. H. Arscott. 1969. Seasonal Decline in Fertility of Turkey Eggs. Poultry Sci., 48: 2109-2113.
3. Holleman, K. A. and H. V. Biellier. 1976a. Fertility and Embryonic Livability as Influenced by Depth of Insemination of Turkey Hens. Poultry Sci., 55: 1154-1156.
4. Holleman, K. A. and H. V. Biellier. 1976b. Importance of Oviduct Relaxation in Artificial Insemination of Turkeys. Poultry Sci., 55: 452-453.
5. Nestor, K. E. and N. Bachev. 1968. The Influence of Sex on Turkey Reproduction. OARDC, Ohio Report on Res. and Develop., 53: 70-71.
6. Nestor, K. E. and K. I. Brown. 1968. Method and Frequency of Artificial Insemination and Turkey Fertility. Poultry Sci., 47: 717-721.
7. Ogasawara, F. X. and W. F. Rooney. 1966. Artificial Insemination and Fertility in Turkeys. Brit. Poultry Sci., 7: 77-82.
8. Parker, J. E. 1947. The Influence of Season on Reproduction in Turkeys. Poultry Sci., 26: 118-121.
9. Touchburn, S. P. and K. E. Nestor. 1971. Effect of Dietary Neomycin-Terramycin on Reproductive Performance in Turkeys. Poultry Sci., 50: 151-155.
10. Wentworth, B. C., M. J. Wineland, and G. D. Paton. 1975. Fertility of Turkey Hens Correlated with Depth of Insemination. Poultry Sci., 54: 682-687.

Progress in Selection for Adaptation of Turkeys to Cages

KARL E. NESTOR and KEITH I. BROWN[1]

INTRODUCTION

Interest in the use of cages for housing growing and breeder turkeys has increased in recent years. At least one major turkey breeder is presently maintaining breeder stock in cages. This breeder has done so for a number of generations.

Previous research (4, 5) generally indicated that the cage environment was stressful to turkeys. Even though the total number of eggs produced may be similar in cage and floor environments, the frequency of non-settable eggs is usually higher for hens housed in cages.

The purpose of this experiment was to study the feasibility of selection for adaptation to the cage environment.

MATERIALS AND METHODS

A single trait selection experiment was started in order to determine the feasibility of selecting turkeys for adaptation to the cage environment. In the base generation, two selected lines (egg and index) and a randombred control population were housed in cages just prior to stimulation into egg production with artificial light. The egg line had been selected for the previous 12 generations for increased egg production in floor pens. The index line had been selected in floor pens for the six prior generations for both increased egg production and increased 16-week body weight using a selection index. The egg line was a medium weight line while the index line was a large bodied line. The randombred control population was also a large bodied line.

In the first generation of selection, a third selected line was added to the study. This medium weight line (low line) had previously been selected for 11 generations for low response to cold stress. Response to cold stress was measured by the level of adrenal hormone (corticosterone) found in blood plasma after 4 hours in a cold environment at 4 weeks of age. Selection for low response to cold stress increased both growth rate and egg production (1, 2).

The experimental plan was to house the randombred control in the cages during the base generation and then again after five generations of selection. This will prevent natural selection from improving performance of the randombred control and, as a result, give a better measure of the progress of the selected lines. However, the progress of the selected lines each generation of selection can not be accurately measured under these conditions.

The offspring used to maintain the selected lines were hatched late in the reproduction period during the first three generations of selection (after 4, 6, and 3 months of production, respectively, for generations 1, 2, and 3). In the first two generations of selection, the offspring were grown in floor pens and placed in cages during the reproduction period. During the third generation, offspring were grown from hatching in a cage environment.

Selection of females in the egg, index, and low lines was based on total production of settable eggs over a 16-week production period beginning with the laying of the first egg by the flock. Female offspring from the highest producing dams were selected. No selection was practiced in the males.

In the first two generations of selection, egg and index line females in cages were mated to selected males of another sample of their respective lines. A random sample of males was selected from the offspring produced by hens in the second generation of selection to mate with females in the third generation. These were maintained in floor pens. In the case of the low line, some selection pressure was applied for increased breast width in the males. The amount of selection pressure varied from generation to generation.

The number of males used in each line varied but there was always a minimum of 12 per line. All males were maintained in floor pens. Semen was pooled within lines prior to insemination.

Hens of all lines were housed in one group of cages in the base and first generation of selection. These lines were housed in another group of cages in the second and third generations of selection. The two groups of laying cages differed in type of floor and rigidity of construction. In the first two generations (base and first generation), the floor type was either plastic coated wire or neoprene coated wire with a rounded upper edge. Unpublished data indicated no difference in frequency of broken eggs with normal shell between the two cage bottoms. In the second and third generations, the wire was coated with a softer neoprene coating and the upper edge was flat. The support for the floor bottom was more rigid in the base and first generations than in the latter two generations.

[1]Associate Professor and Professor and Associate Chairman, respectively, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

The total number of eggs laid and the frequency of normal eggs were measured over a 16-week production period beginning with the laying of the first egg by the flock. In addition, the frequency of broken eggs with normal shells, weak-shelled eggs (eggs with some shell but which break easily), membrane eggs (no shell), and slab-sided eggs (eggs with a compressed side due to the presence of two eggs in the oviduct at the same time) were also summarized. Broodiness and intensity of lay (clutch length) measurements were obtained from the egg production records by the method of Nestor (3).

RESULTS AND DISCUSSION

The total egg production and the frequency of normal eggs for the base generation and first three generations of selection are presented in Table 1. In the base generation, egg production of the egg line, randombred control, and index line was 75, 55, and 51 eggs per hen, respectively. For comparison in floor pens, the control line and index line averaged 66 and 63 eggs per hen, respectively, for a 120-day period (8 days longer than the 16 weeks used in this study). Thus, it appears that the cage environment reduced egg production of these two lines to a great extent. On the other hand, the egg line hens housed in floor pens laid 79 eggs in a 120-day period, which is about the same production level as observed in cages. However, the floor hens were not treated for broodiness whereas the cage hens were.

Previous comparisons (4) have indicated that egg line hens produce about the same number of total eggs whether housed in cages or in floor pens. Although comparisons between generations can be influenced by environmental differences between years, there appeared to be no trend in the total number of eggs produced by egg line hens. The index line appeared to gain six eggs per hen in the first generation and remain constant in the second generation, with a further increase of three eggs in the third generation of selection. The low line did not appear to change in total number of eggs produced in the first two generations of selection. When the offspring were taken from hatches later in the laying period, the reproduction of the index and low lines was lower, resulting in a reduction of the number of hens housed for these lines.

The percentage of normal eggs laid by egg line hens appeared to increase in the first generation of selection (Table 1). Although there seemed to be another increase in the second generation, a different group of cages was used to house the hens in the second generation and the differences may have been due to differences between types of cages. There was a 2% increase in frequency of normal eggs between the second and third generations. The frequency of normal eggs for the large bodied index line was high in the base generation and appeared to decrease slightly in the first generation. Increases were also noted for the index line in the second and third generations. The average frequency of normal eggs laid by low line hens was less than that for hens of the other two lines and increased during the first two generations of selection. As noted above, the increase between the first and second generations might be attributed to differences in the construction of the cages used during the 2 years.

The non-settable eggs laid by the caged hens were grouped into the following classes: 1) broken with normal shell (measurements on the shell indicate that these eggs have a normal amount of shell); 2) weak-shelled eggs (have some shell but break easily); 3) shell-less or membraneous (no shell present); and 4) slab-sided (eggs with a compressed side due to the presence of two eggs in the oviduct). The eggs were recorded and any which had broken and fallen onto the manure below were removed to prevent recording duplications.

There appeared to be a large difference between the two types of cages in the frequency of broken eggs with normal shell (base and first generations vs. second and third generations) (Table 2). Selection appeared to lower the frequency of broken eggs in the

TOTAL 1.—Total Egg Production and Frequency of Normal Eggs in the Base Generation and the First Three Generations of Selection.

	No. of Hens				Total 16-Week Egg Production (No./Hen)				Normal Eggs (%)			
Line	Base	1	2	3	Base	1	2	3	Base	1	2	3
Egg	47	70	78	48	75	73	73	73	74	84	90	92
Index	47	36	29	43	51	57	57	61	89	85	95	95
Low		35*	30†	51‡		66*	58†	67‡		77*	85†	90‡
Control	47				55				78			

*Base generation for low line.
†First generation of selection for low line.
‡Second generation of selection for low line.

TABLE 2.—Frequency of Various Types of Abnormal Eggs in the Base Generation and the First Two Generations of Selection.

Line	Broken Eggs with Normal Shell (%)				Weak-shelled (%)				Shell-less (%)				Slab-sided (%)			
	Base	1	2	3	Base	1	2	3	Base	1	2	3	Base	1	2	3
Egg	12.8	7.1	2.0	0.5	6.1	4.0	*	0.8	2.0	1.2	1.3	1.8	4.7	3.2	6.3	3.7
Index	6.7	8.2	2.3	1.4	1.4	3.4	*	0.6	1.9	1.0	1.1	1.4	0.7	1.9	1.6	1.9
Low		9.7†	2.6‡	1.2**		4.6†	*	2.0**		2.4†	1.7‡	2 3**		6.3†	10.8‡	4.8**
Control	13.3				2.4				3.1				3.2			

*Included in other categories of abnormal eggs.
†Base generation of low line.
‡First generation of selection in low line.
**Second generation of selection in low line.

first generation of selection in the egg line. There appeared to be no change in the index line during these generations. The frequency of weak-shelled eggs decreased in the egg line and increased in the index line between the base and first generations. There was a decrease in all lines in the third generation of selection. By error this shell type was not recorded in the second generation and these eggs were probably included in both the shell-less and slab-sided eggs. Many slab-sided eggs could also be classified as weak-shelled. The frequency of shell-less eggs did not differ greatly between lines or between generations. The amount of slab-sided eggs was greatest in the low line and lowest in the index line, with the egg line being intermediate. The higher frequency of these eggs in the second generation may have been the result of differences in cages or the error in classification or both.

The egg production records were analyzed for intensity of lay and broodiness. Hens were treated for broodiness once a week. Any hen which had not laid for 5 consecutive days was removed to a broody floor pen and given high intensity light for 40 hours. Intensity of lay was measured by the average length of the clutches. A clutch is defined as the number of eggs laid on consecutive days before skipping 1 or more days. The results of Nestor (3) indicated that average clutch length was the best measure of intensit of lay. Broodiness was measured by the total number of days lost from pauses of 5 or more consecutive days (best measure of broodiness (3)).

The average clutch length was higher in the egg line than in the other two lines which had similar average length (Table 3). There was no apparent trend with generations. The total days lost from broodiness were highest in the index line and lowest in the egg line. Broodiness may have increased slightly in the egg and low lines and decreased in the index line.

TABLE 3.—Intensity of Lay (Average Clutch Length) and Total Days Lost from Broodiness in the Base Generation and the First Two Generations of Selection.

Line	Average Clutch Length (No. of Eggs)			Total Days Lost from Broodiness		
	Base	1	2	Base	1	2
Egg	2.75	2.76	2.73	3.8	13.5	11.6
Index	1.96	2.12	2.07	28.1	27.1	20.4
Low		2.00	2.09		10.9	17.0
Control	2.15			26.5		

The results of this experiment indicate that the cage environment places a stress on turkey hens. Selection for increased number of settable eggs may result in an increase in total eggs or frequency of settable eggs or both, depending on the level of performance of the lines being selected.

SUMMARY

A selection experiment was initiated to adapt turkeys to cage rearing. Selection was practiced for increased number of settable eggs in two medium weight lines and one large bodied line. The results of the first three generations of selection suggest that the total number of eggs (normal plus abnormal) increased in the large bodied line, with possibly no change in frequency of normal eggs. In the medium bodied lines, selection did not change total number of eggs but increased the frequency of settable eggs.

LITERATURE CITED

1. Brown, K. I. and K. E. Nestor. 1973. Some Physiological Responses of Turkeys Selected for High and Low Adrenal Response to Cold Stress. Poultry Sci., 52: 1948-1954.
2. Brown, K. I. and K. E. Nestor. 1974. Implications of Selection for High and Low Adrenal Response to Stress. Poultry Sci., 53: 1297-1306.
3. Nestor, K. E. 1972. Broodiness, Intensity of Lay and Total Egg Production of Turkeys. Poultry Sci., 51: 86-92.

4. Nestor, K. E. and W. L. Bacon. 1972. Production of Defective Eggs by Egg and Meat Type Turkeys. Poultry Sci., 51: 1361-1365.

5. Woodard, A. E., H. Abplanalp, and F. X. Ogasawara. 1961. Egg and Semen Production Performance of Turkeys Under Cage Management. Poultry Sci., 40: 884-890.

Non-producing Turkey Hens

KARL E. NESTOR, CHARLES F. STRONG, Y. M. SAIF,
and PHILIP A. RENNER[1]

INTRODUCTION

The occurrence of hens which laid only very few or no eggs was observed during several generations of trapnesting turkey hens in a genetic study. Since these hens result in an economic loss to hatching egg producers, a survey of causes of non-production was made to determine if the frequency of these hens could be reduced.

MATERIALS AND METHODS

The egg production records of 10 lines of turkeys on genetic studies were observed after the majority of the hens had been in egg production for about 2 months. All hens were given stimulatory lighting of 14 hours per day at approximately 42 weeks of age. Egg production of the various lines ranged from very high in the line selected for increased egg production (1) to very low in the line selected for increased 16-week body weight (2). After it was determined that a hen was not laying eggs on the floor and the hen had not laid or laid less than five eggs during the first 2 months of production, she was autopsied to discover the cause of the abnormally low or non-production.

RESULTS AND DISCUSSION

There were 19 non-producing or abnormally low egg producers out of a total of 830 hens during a 2-year period. Thus, 2.3% of all hens fell into this category.

Four of the 19 abnormal females (21.1%) had immature reproductive systems. Of these, no ovary or testes could be observed on macroscopic observation in three hens. A very infantile oviduct was observed in three of the four hens.

Tears in the oviduct occurred in 3 of the 19 abnormal hens (15.8%), allowing the yolks to enter the body cavity. Two tears occurred in the magnum region (albumen producing area) and the other occurred in the uterus (shell forming area).

Adhesions occurred in the oviducts of four hens (21.1%). In one hen which had laid two eggs, the adhesion occurred between the uterus and vagina. One hen had a branched infundibulum and neither branch had an opening. In another hen, the oviduct was completely duplicated (normally only left oviduct present) and neither oviduct had an opening in the vagina. This hen had only one ovary. A small

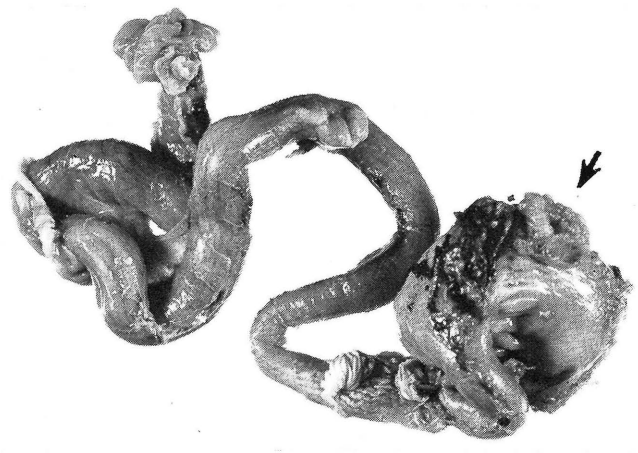

FIG. 1.—Oviduct of hen having a vagina which was internal (see arrow) as well as the normal vagina.

egg with albumen, shell, and shell membranes but no yolk was present in the uterus of the left oviduct. The vagina in the fourth hen was elongated and was occluded.

One non-producing hen (5.3%) had a normal ovary but the oviduct had two vaginas with one located in the body cavity (see arrow, Fig. 1). Eggs formed by this hen, after entering the oviduct at the infundibulum, exited through the internal vagina resulting in an unusual internal layer.

One hen (5.3%) had two huge ova (the two ova on right, Fig. 2) in rapid development in the ovary. These ova weighed 134 and 121 grams, respectively, whereas the normal maximum weight for ova just prior to ovulation for this weight bird was 30 grams or less. Both ova had distinct stigmas. This hen also had six normal sized ova in rapid development. The largest was 28 grams (left ovum, Fig. 2). There

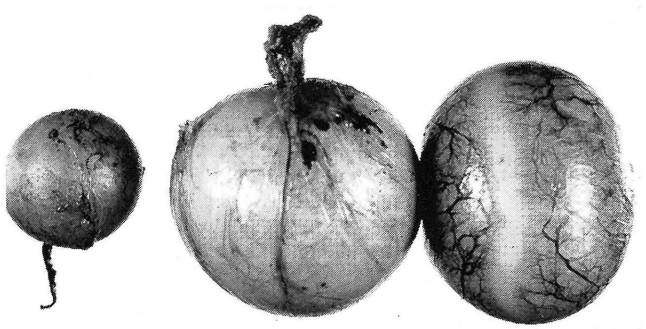

FIG. 2.—Two large ova in comparison to a normal sized ovum found in one non-laying hen.

[1]Associate Professor, Graduate Research Associate, Associate Professor, and Instructor, respectively, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

was one ovum in a state of deterioration. It appeared that this hen did not ovulate the ova for some unknown reason and they continued to grow to abnormal size.

One hen (5.3%) had an apparently normal oviduct, but after shell was placed on the egg, the eggs returned back up through the oviduct and entered the body cavity. There were three hard-shelled eggs and two other yolks in the body cavity.

The remaining five hens (26.3%) had normal oviducts but the ovaries of these hens were not functioning properly. One ovary was cystic while the other four were in various stages of deterioration.

The causes of the reproductive disorders described above are unknown. However, it is known that growth selection did not increase the frequency because 10 of 360 (2.8%) medium-bodied hens were abnormal while only 9 of 470 (1.9%) large-bodied hens exhibited such abnormalities.

SUMMARY

Nineteen non-producing hens were found out of a total of 830 hens. The causes of non-production included lack of development in the reproduction system (21%), tears in oviduct (16%), adhesion in oviduct (21%), abnormally formed oviduct (5%), lack of ovulation of developed ova in ovary (5%), return of egg after shell formation back to body cavity (5%), and abnormal ovaries (26%).

LITERATURE CITED

1. Nestor, K. E. 1971. Genetics of Growth and Reproduction in the Turkey. 3. Further Selection for Increased Egg Production. Poultry Sci., 50: 1672-1682.
2. Nestor, K. E. 1977. Genetics of Growth and Reproduction in the Turkey. 5. Selection for Increased Body Weight Alone and in Combination with Increased Egg Production. Poultry Sci., 56: (in press).

Inheritance of Leg Muscle Measurements in Live Turkeys

KARL E. NESTOR and PHILIP A. RENNER[1]

INTRODUCTION

Leg weakness is a major problem of male turkeys during the growing and breeding periods. Numerous factors including nutrition, disease, management, genetics, etc. may be responsible for a portion of the leg weakness encountered in turkeys.

Most of the emphasis of breeders of large white turkeys has been on increasing body weight and the amount of breast muscle. Although the weight of leg muscle increases with increases in total body weight, the relative amount based on a percent of body weight actually decreases (1, 2). Leg weakness in large weight turkeys may therefore be due in part to the relatively lighter muscled legs found in these turkeys.

Several body measurements (body depth, breast width, shank length, shank width, drumstick length, drumstick circumference, and drumstick width) were measured on live birds and correlated with the percent of leg muscle in a previous study (3). Drumstick circumference and drumstick width, measured side-to-side, were strongly associated positively with percent leg muscle and appeared to be the best indicators of percent leg muscle in the live bird. However, these two measures had only moderate to low repeatabilities. Repeatability estimates the variation of different measurements on the same bird. With low repeatabilities, several measures on the same bird are required to obtain precise estimates, while with higher repeatabilities one or two measurements are required in order to obtain the same accuracy. The repeatabilities of drumstick width and drumstick circumference were 0.31 and 0.44, respectively, while that for 24-week male body weight was 0.98.

MATERIALS AND METHODS

The inheritance of drumstick width and drumstick circumference measurements on live birds was studied using a large bodied randombred control population of turkeys. Thirty-six full sib families were used. Since the original theory suggested that the percent of leg muscle was decreasing as body weight increased, changes in leg muscle independent of body weight would be desired. Therefore, the data collected were adjusted for differences in body weight by statistical analysis prior to studying genetic variation in the two traits. Measurements were made on two or three individuals of each sex for each family. The sexes were analyzed separately. Only one measurement was made on each bird. The measurements were made at 24 weeks of age.

[1]Associate Professor and Instructor, respectively, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

RESULTS AND DISCUSSION

Significant family differences were observed in both drumstick width and drumstick circumference for males. For females, differences among families were significant only for drumstick circumference. Heritability estimates, which measure the genetic variation in a trait, were low for all of these measures. For males, the estimates were 0.10 for drumstick width and 0.12 for drumstick circumference. The female drumstick circumference had a heritability of 0.23.

With the low magnitude of these estimates, little genetic progress would be made by selection for increased leg muscle based on measurements made on live birds, particularly in males which are more critical because of the much greater frequency of leg weakness occurring in this sex. The relatively low heritability of the leg measurements after adjustment was made for differences in body weight could be the result of low genetic variation for these traits or to the relatively low repeatability of these traits. The heritability estimates may have been larger if more than one measurement was made on each bird. Repeated measurements would be more time consuming and partially defeat the purpose of making the measurements on the live birds.

An experiment is planned to estimate the heritability of the actual weight of leg muscle obtained after autopsy. The results of this experiment should answer the question whether the relative amount of leg muscle can be changed by selection without changing body weight.

SUMMARY

The inheritance of drumstick width, measured side-to-side, and drumstick circumference at the largest point measured on the live bird was studied in a large-bodied randombred control strain. Heritability estimates were low (0.10, 0.12, and 0.23, respectively) for male drumstick width, male drumstick circumference, and female drumstick circumference. Since there were no significant differences between families for female drumstick width, the heritability estimate was not calculated.

LITERATURE CITED

1. Marsden, S. J. 1940. Weights and Measurements of Parts and Organs of Turkeys. Poultry Sci., 19: 23-28.
2. Miller, B. F. 1968. Comparative Yield of Different Size Turkey Carcasses. Poultry Sci., 47: 1570-1574.
3. Nestor, K. E., P. A. Renner, and D. A. Ehlhardt. 1974. Association of Certain Body Measurements on Live Birds with the Amount of Leg Muscle in the Turkey. Ohio Agri. Res. and Dev. Center, Res. Sum. 80: 67-71.

The Influence of Long Term Selection for Increased Egg Production and Increased Body Weight in the Turkey

KARL E. NESTOR[1]

INTRODUCTION

It is well known that egg production, and as a result poult production of turkeys, is relatively poor, resulting in high poult costs. Generally, any change in egg production is associated with a similar change in poult production (1, 3, 7).

The purpose of this study was to evaluate the effects of long term selection for increased egg production alone, increased body weight alone, and both increased body weight and increased egg production simultaneously.

MATERIALS AND METHODS

One selection experiment was initiated in 1960 in which a line was developed from a medium weight randombred control population (this population was considered large bodied in 1960) by selection only for increased egg production. The selection criterion in the first three generations of selection was egg production for a 84-day period beginning with the production of the first egg in the flock. Selection was based on egg production of survivors for a 180-day production period in later generations of selection. Offspring of the highest producing dams were used to produce the next generation.

A paired mating system (2) in which one male was mated at random to only one female (except that full brother-sister matings were avoided) was used to reproduce the egg line. The number of parental pairs used varied from 36 to 72 in different generations. Offspring from approximately one-fourth of the highest producing females were selected each generation.

The randombred control population, which served as the base population for the egg line, was maintained along with the egg line. The control population was reproduced by use of a paired mating system similar to the egg line except the number of parental pairs varied from 36 to 48 in different generations. One male and one female offspring from each family were randomly selected, if available, in each generation to reproduce the randombred controls. Very little genetic change was expected in the controls over the 16 generations of this study (5). Therefore, yearly differences in averages for the randombred control should represent environmental differences. Values for the egg line were expressed as deviations from similar values for the randombred controls in order to remove yearly effects resulting from environmental variation.

The influence of selecting solely for increased 16-week body weight or for both increased 16-week body weight and increased 180-day egg production was studied in another selection experiment. The lines were developed from a large-bodied randombred control population (8). A paired mating system using 36 pairs of parents was used for both selected lines and the randombred control in all generations. Egg production was measured for a 180-day period in all generations. Mass selection for only increased body weight was made in one line (16-week). In the other selection line (index), individuals were mass selected on the basis of a selection index which gave three times the emphasis on the individual's 16-week body weight as on its dam's 180-day egg production.

RESULTS AND DISCUSSION

Egg production of the egg line hens for the short 84-day production period increased consistently relative to the randombred control hens in the first five

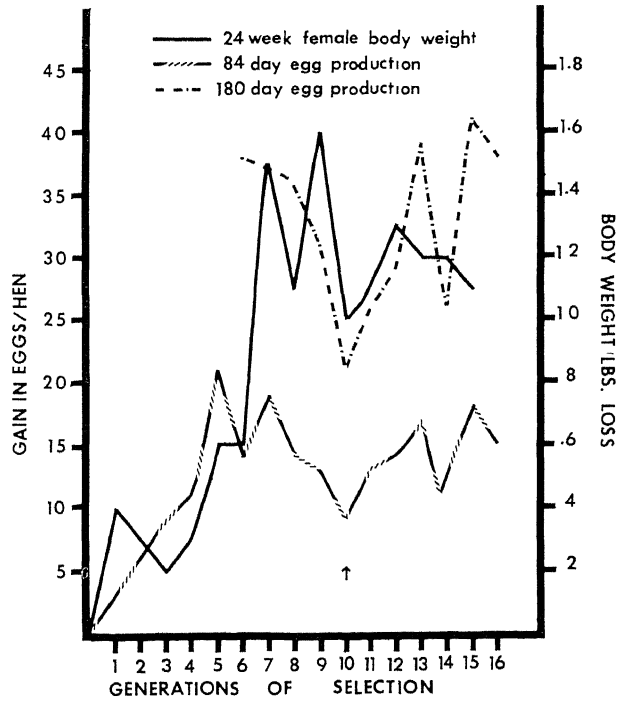

FIG. 1.—Long term selection for increased egg production.

[1]Associate Professor, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

generations of selection and, possibly, increased for the first seven generations (Fig. 1). The value obtained for the difference between the egg and control lines in generation five was abnormally high, presumably due to the unusually low egg production of the control hens. If this apparently abnormal generation is not considered, the increase in 84-day egg production occurred until the seventh generation of selection. No egg production data for 180 days of production were available for the two lines during the first three generations of selection in the egg line. In the fourth generation, only data for egg line females were collected. Values for the fifth generation were not plotted in Figure 1 due to the abnormally low egg production of the control line resulting in an apparently large gain for the egg line.

The 84-day egg production of the egg line expressed as the difference from the control line began to decline after the seventh generation of selection (Fig. 1). A decline in 180-day egg production was evident by the seventh generation of selection.

Both lines were housed in a wood-framed conventional breeder house in the first five generations. In the sixth generation and later, hens of both lines were housed in a windowless breeder house and were given an improved broody hen management program during the reproductive period (6). This tended to favor the more highly broody hens from the control line. Also, the use of this improved system allowed offspring of some egg line hens which went broody to be selected as breeders. In the tenth generation of selection and later, no treatment was given to broody egg line hens although the randombred control hens were treated as before. This resulted in an apparent loss of ten eggs per hen for the egg line between the ninth and tenth generations of selection (Fig. 1) during the 180-day production period.

Progress from selection was great from the 10th through the 13th generations of selection in the egg line (Fig. 1). In fact, the rate of gain during this period was as great for 84-day egg production as was observed during the first few generations of selection. These results indicate that the genetic variation in egg production had not decreased as a result of the prior ten generations of selection. The apparent large decrease in egg production in the 14th generation probably was not a true genetic effect since the egg production of the egg line in the 15th and 16th generations was at approximately the same level as in the 13th generation. It appears that a plateau in response to selection may be occurring in the later generations.

Egg production of the egg line relative to the randombred control may be more erratic between generations when broody hens of the egg line are not treated. Some egg line hens lay a few eggs, go broody, and are out of production for the remainder of the production period. A difference in the number of such hens can greatly increase the variation in average egg production between generations of the egg line, particularly for the longer 180-day production period. Since the randombred control hens were treated for broodiness in each generation, the number of hens laying only a few eggs was not great and the frequency of these hens did not vary to a great extent from generation to generation. The number of egg line hens which went out of production early in the laying period varied from 4 to 12 out of a total of 72 hens.

In the 16th generation, a sample of randombred control hens were not treated for broodiness. The 84-day egg production of these hens averaged 40 vs. 44 for the sample of control hens which were treated for broodiness. For the 180-day production period, non-treated control hens averaged 71 vs. 81 for the treated hens, a difference of 10 eggs per hen. If all of this difference could be gained by the egg line by treating for broodiness, the 180-day egg production for the egg line would have been 48 eggs per hen superior to that of the control line in the 16th generation. However, it is unlikely that treating broody hens in the egg line would increase the average production by 10 eggs per hen because many hens in the egg line are non-broody.

One interesting point concerning non-treated hens in the egg line is that many of these hens exhibit classic signs of broodiness (frequent nesting, hissing, ruffled feathers, etc.) but never cease laying, which suggests that different mechanisms exist for broody behavior and cessation of egg production in broody turkey hens. Broody behavior by laying hens is undesirable because the frequent nesting increases the labor involved in trapnesting.

Body weight did not change greatly in the egg line during the first four generations of selection (Fig. 1). Most of the gains observed in egg production during this time were attributed to a genetic reduction in broodiness. The gains in egg production observed from the fourth through the seventh generations were associated with some further decrease in broodiness and a major increase in intensity of lay as measured by the average length of the clutch (the number of eggs laid on consecutive days before skipping 1 or more days). There was a major reduction in body weight over these generations. This suggests that the genetic decrease in body weight may have been associated with the increase in intensity of lay.

The loss in body weight in the egg line fluctuated between 1.0 and 1.6 lb. for females during the 7th through the 16th generations of selection. The results in the last four generations suggest that the loss

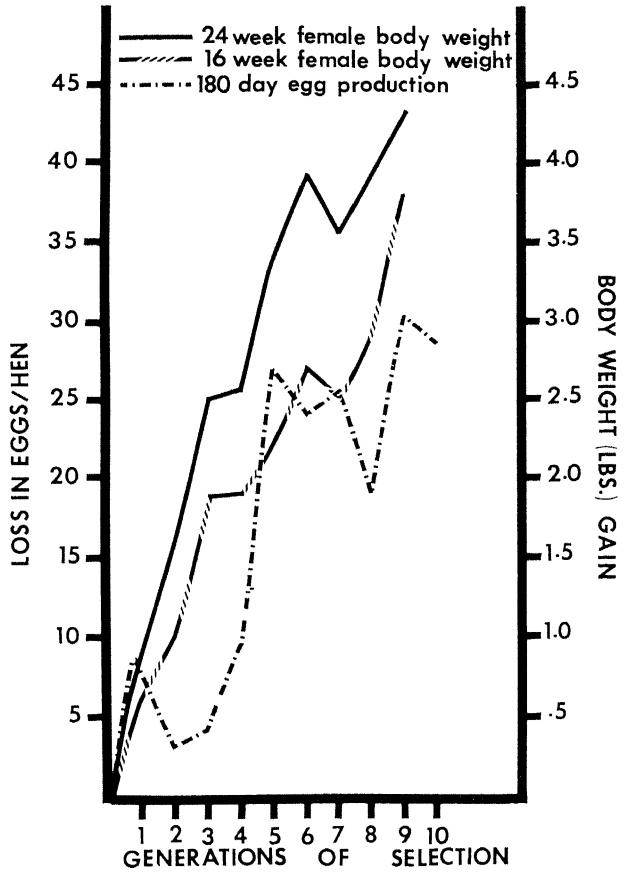

FIG. 2.—Long term selection for increased 16-week body weight.

was between 1.1 and 1.3 lb. and has stabilized. It is noteworthy that during the large gain in egg production from the 10th through the 16th generations, no further loss in body weight occurred. The gain in egg production in the egg line was mainly from a reduction in broodiness, thus further strengthening the theory that there is no genetic relationship between broodiness and body weight.

Sixteen-week body weight of 16-week line females increased consistently over the first nine generations of selection (Fig. 2). There was no evidence of any plateau in response to selection. Since similar results were observed for males, this data were not presented. Body weight at 24 weeks of age showed similar changes as 16-week body weight. The gains in body weight were accompanied by major losses in egg production after the third generation of selection. The rate of loss in egg production appeared to decrease from the fifth through the tenth generations of selection in the 16-week line. At the present time, this line has lost approximately 30 eggs per hen during a 180-day production period while gaining about 3.8 and 4.3 lb., respectively, in body weight of females at 16 and 24 weeks of age.

Although the total days lost from broodiness increased at the rate of 2.4 days per generation of selection in the 16-week line, the linear trend was not statistically significantly different from zero. The average length of each clutch in the 16-week line decreased at the rate of 0.08 egg per generation and this trend was significantly different from zero. These results tend to confirm the theory presented earlier that body weight is negatively correlated genetically with intensity of lay but is not correlated with broodiness.

To further test this, genetic correlations were estimated between female 16-week body weight and reproduction traits. These were estimated by regressing the genetic gain for the secondary trait (reproductive trait) on the genetic gain of the primary trait (16-week body weight) when both traits were adjusted for differences in variance. Several measures of intensity of lay and broodiness were studied. The measures of intensity of lay included number of clutches, average clutch length (which was considered the best measure of intensity of lay (4)), the length of the longest clutch (maximum clutch length) and rate of lay (egg production per hen per day after total days lost from broodiness was subtracted from total days in laying period). Broodiness measures included number of broody periods of 5 or more consecutive days, average length of broody periods, total days lost from broodiness (considered best measure of broodiness (4)), and effective length of laying period (180 days minus days lost from pauses of 5 or more days at end of period). Other reproduction data (percent fertility, percent hatch of fertile eggs, and poults produced per hen) collected over a 12-week hatching season at the beginning of lay were included in the analysis.

Genetic correlations measure the expected changes in one trait when selection is placed on another trait. The magnitude varies from —1.0 to +1.0. A negative genetic correlation between two traits indicates that as one trait increases genetically the other trait declines. A positive genetic correlation indicates that both traits move up and down together. The closeness of the relationship is indicated by the magnitude of the correlation varying from zero (no association) to 1.0 (maximum association which indicates that the two traits are the same).

Female 16-week body weight was strongly correlated negatively with total egg production (Table 1) as indicated in Figure 2. The genetic association of body weight and average length of clutches, maximum clutch length, and rate of lay were all negative and significantly different from zero. No significant genetic correlation was observed between body weight and number of clutches (which is influenced by total

TABLE 1.—Genetic Correlation of Female 16-Week Body Weight and Reproduction Traits.

Reproduction Trait	Correlation	Standard Error
180-Day Egg Production	—0.42	0.12**
No. Clutches	+0.01	0.33
Ave. Clutch Length	—0.63	0.19*
Maximum Clutch Length	—0.55	0.19*
Rate of Lay	—0.50	0.06**
No. Broody Periods	—0.26	0.12
Ave. Length Broody Periods	—0.04	0.09
Total Days Broody	+0.21	0.13
Effective Length of Period	—0.11	0.10
Percent Fertility	—0.18	0.12
Percent Hatch of Fertile Eggs	0.00	0.08
Poults per Hen	—0.49	0.11**

*Genetic correlation is significantly different from zero.
**Genetic correlation is highly significantly different from zero.

days lost from broodiness) and body weight and broodiness traits. Percent fertility and hatchability were not generally correlated significantly with body weight. The number of poults produced per hen was strongly correlated negatively with body weight,

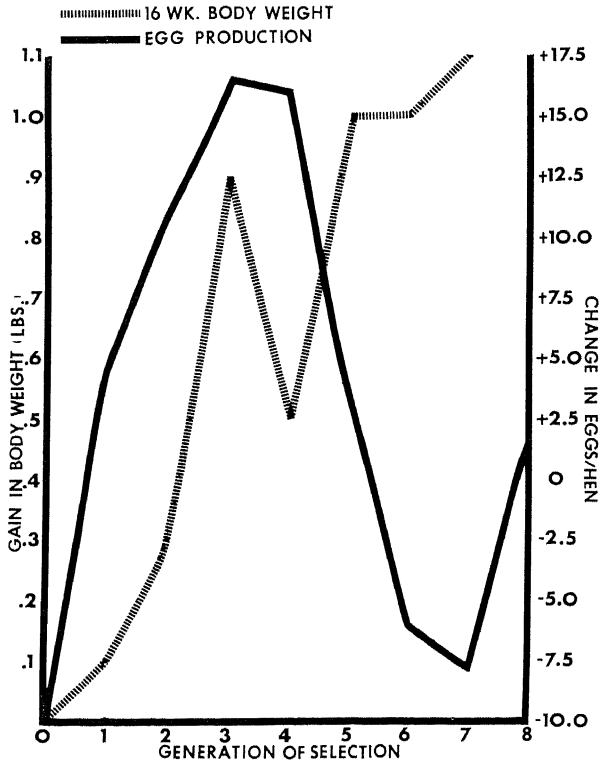

FIG. 3.—Influence of selection for both increased egg production and increased 16-week body weight by means of a selection index.

probably the result of the strong negative correlation between body weight and egg production.

Selection for both increased body weight and increased egg production resulted in an increase in both traits for the first three generations of selection (Fig. 3). In later generations, the average body weight continued to increase while the gain in egg production was lost by the eighth generation of selection.

The results in all three selected lines (egg, 16 week, and index) were similar in that during the first few generations of selection there appeared to be little genetic association between body weight and egg production, whereas in later generations of selection there appeared to be a negative genetic relationship between the two traits. These results can be explained by lack of genetic correlation between body weight and broodiness and a negative genetic correlation between intensity of lay and body weight.

SUMMARY

The results of two long term selection studies for increased egg production and increased 16-week body weight suggest that body weight is negatively correlated with intensity of lay but is not correlated with broodiness traits. Therefore, if broodiness could be decreased in the absence of genetic changes in intensity of lay, egg production could be increased without a reduction in body weight. This is being tested in other selection studies.

LITERATURE CITED

1. Clayton, G. A. 1962. Estimates of Some Parameters Concerning Fecundity in Turkeys. Brit. Poultry Sci., 3: 3-7.
2. Jaap, R. G. 1963. Paired Matings for Control and Selected Populations of Chickens. Poultry Sci., 42: 1027-1028.
3. MacIver, R. M. 1967. Part Record Selection for Fecundity in Turkeys. Brit. Poultry Sci., 8: 83-89.
4. Nestor, K. E. 1972. Broodiness, Intensity of Lay and Total Egg Production of Turkeys. Poultry Sci., 51: 86-92.
5. Nestor, K. E. 1977. The Stability of Two Randombred Control Populations of Turkeys. Poultry Sci., 57: 54-57.
6. Nestor, K. E. and P. A. Renner. 1966. New Management System for Broody Turkey Hens. Ohio Agri. Res. and Dev. Center, Ohio Report on Res. and Dev., 51 (6): 83-85.
7. Nestor, K. E., K. I. Brown, and C. R. Weaver. 1972. Egg Quality and Poult Production in Turkeys. 2. Inheritance and Relationship Among Traits. Poultry Sci., 51: 147-158.
8. Nestor, K. E., M. G. McCartney, and N. Bachev. 1969. Relative Contributions of Genetics and Environment to Turkey Improvement. Poultry Sci., 48: 1944-1949.

Adenovirus-like Particles Associated with a Respiratory Disease in Turkey Poults

Y. M. SAIF[1]

INTRODUCTION

Adenoviruses have been implicated as causative agents of inclusion body hepatitis in chickens, quail bronchitis, marble spleen disease of pheasants, and hemorrhagic enteritis of turkeys. There are also reports of losses in egg production and respiratory syndromes in chickens caused by different serotypes of adenoviruses. Several serotypes of adenoviruses are recognized and it has been reported that more than one serotype can be isolated from healthy or sick chickens. It has been shown on the basis of serologic testing that adenoviruses are widespread in chicken and turkey flocks.

Except for the well-recognized hemorrhagic enteritis syndrome, the significance of adenovirus infections in turkeys is not very clear. Recently Simmons *et al.* (2) isolated an adenovirus from turkey poults with respiratory signs of rales and increased lacrimal discharges but were not successful in reproducing the disease in young poults. Hofstad *et al.* (1) reported on a similar syndrome in 3 and 9-week-old poults. The clinical signs detected included nasal discharge, wet eyes, and coughing.

This report deals with natural outbreaks of a respiratory disease in poults from which an adenovirus-like agent was detected and attempts to reproduce the disease in specific pathogen-free poults.

Natural Outbreaks

In 1975 outbreaks of a respiratory disease were investigated in a commercial turkey flock which exhibited signs similar to those described previously. This flock had different age groups of turkeys and the observation was made that after the end of the brooding period there was increased mortality, general unthriftiness, increased incidence of litter eating, and respiratory rales. On close examination, it was observed that most of the birds had sinusitis. Watery or mucoid secretions were easily expelled from the nostrils by applying pressure.

Attempts were made to determine the nature of the agent causing this syndrome. Sera from the birds were tested for antibodies against *Mycoplasma gallicepticum, M. synoviae, M. meleagridis,* and Influenza A virus. Only antibodies against *M. meleagridis* were detected in the sera. *M. meleagridis* was isolated from the air sacs, sinuses, and tracheas of some of these birds, but it was felt that this organism was not the cause of this syndrome. No bacteria were isolated from the air sacs, livers, or lungs but a variety of bacteria were isolated from the nasal exudate. Again, no significance was attached to the presence of these bacteria other than being secondary invaders. The nasal exudate from affected poults was filtered to remove all bacteria and a cell-free preparation was examined by an electron microscope. Typical adenovirus-like particles were detected in the nasal exudate as shown in Figure 1.

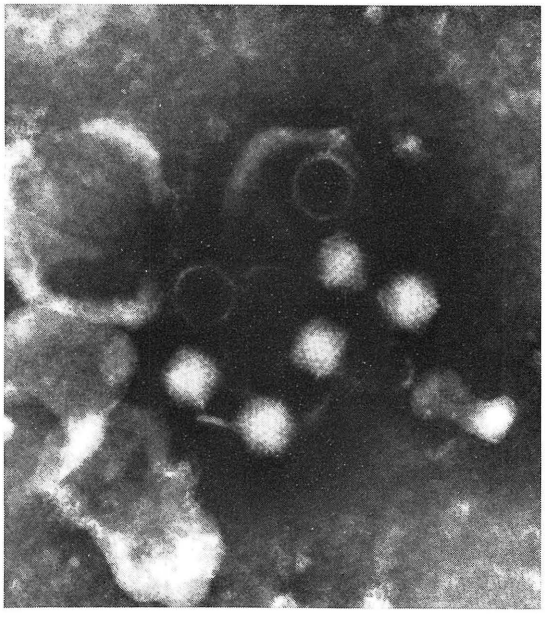

FIG. 1.—Adenovirus-like particles detected in nasal exudate. 135,000X.

MATERIALS AND METHODS

Following the demonstration of the adenovirus-like particles, attempts were made to reproduce the disease in specific pathogen-free (SPF) turkey poults. The SPF turkey flock which has been maintained at the OARDC since 1965 was shown to be free of adenovirus antibodies. It was postulated that these birds should be highly susceptible to adenoviruses as compared to commercial turkeys where the infection is apparently common.

Nasal exudate from the naturally infected birds that was filtered to remove bacteria was used to inoculate groups of SPF turkey poults intranasally. The birds ranged in age from 1 to 3 weeks.

[1]Associate Professor, Departments of Poultry Science and Veterinary Science, Ohio Agricultural Research and Development Center.

TABLE 1.—Results of Poult Inoculation with Sinus Exudate Containing Adenovirus-like Particles.

Exp. No.	Treatment	No. of Birds	Age/Days	No. of Birds Exhibiting Sinusitis
1	Naturally infected	2	22	2
	Contact controls	8	14	5
2	Inoculated	10	21	3
	Contact controls	5	21	2
	Non-inoculated controls	10	21	0
3	Inoculated	3	7	3
	Contact controls	9	7	5
	Non-inoculated controls	4	7	0

RESULTS AND DISCUSSION

The results of the experiments are presented in Table 1. In the first experiment, two of the naturally infected birds were placed in contact with eight SPF poults. Five of the contact birds developed sinusitis. In the other two experiments, some of the inoculated and contact control birds developed sinusitis but none of the non-inoculated control birds was affected. It is interesting to note that the sinusitis noticed in the inoculated and contact birds was milder than that observed in the naturally infected birds. It is possible that the environmental conditions and secondary infections in field outbreaks do contribute to the severity of the disease. The observation that in the field the disease developed after the birds were moved from heat enclosed housing into open type pole barns and the owners' report that mortality increased following drastic changes in the weather lend credence to this suggestion.

SUMMARY

An adenovirus-like agent was found in nasal exudate from turkey poults affected with a respiratory disease. Cell-free filtrates from the nasal exudate were used to inoculate SPF turkey poults. Some of the inoculated poults and their contact birds developed sinusitis. The disease in inoculated birds was milder than that observed in the field. It is suggested that stressful conditions and secondary infection can aggravate the disease, causing the clinical signs and lesions observed in natural outbreaks.

LITERATURE CITED

1. Hofstad, M. S., A. E. Ritchie, and H. T. Hill. 1975. Turkey Coryze—A New Disease of Young Turkeys. Proc., 26th Annual NC Poultry Disease Conference.
2. Simmons, D. G., S. E. Miller, J. G. Gray, H. G. Blalock, and W. M. Colwell. 1976. Isolation and Identification of a Turkey Respiratory Adenovirus. Avian Dis., 20.

Effects of Various Levels of Dietary Calcium and Phosphorus on Performance of Japanese Quail Laying Hens

AUSTIN H. CANTOR[1]

INTRODUCTION

Recent studies with both chickens and turkeys have shown that the requirement for dietary phosphorus is lower than previously established values. It has been common to use levels of 0.45% to 0.55% available phosphorus in diets for laying hens, layer and broiler breeders, and turkey breeders. Scott *et al.* (2) found that 0.26% available phosphorus yielded the best egg production, feed conversion, and shell breaking strength in SCWL hens fed a diet containing 3.5% calcium. Waldroup *et al.* (3) found 0.3% inorganic phosphorus to be sufficient to maintain egg production, fertility, hatchability, and egg shell thickness of caged turkey breeder hens fed diets containing 2.25% calcium. A level of 0.2% inorganic phosphorus was adequate in hens fed 3.5% calcium. The National Research Council (1) does not list the calcium and phosphorus requirements of Japanese quail breeders.

[1]Assistant Professor, Dept. of Poultry Science, Ohio Agricultural Research and Development Center.

The purpose of this study was to examine the effects of various levels of calcium and phosphorus on the performance of Japanese quail laying hens.

MATERIALS AND METHODS

Four experimental practical type diets were calculated using a least cost linear program to provide two levels of calcium (2.25%, 2.75%) and two levels of available phosphorus (0.3%, 0.6%) in a factorial arrangement. All four experimental quail breeder diets were calculated to be isocaloric and equal in their content of protein, methionine + cystine, and lysine (Table 1).

The quail were raised in battery brooders and given natural light from 0 to 4 weeks of age (month of November) and 6 hours of artificial light from 4 to 7 weeks of age. They were fed practical starter diets from 0 to 7 weeks of age. The hens were transferred to individual laying cages and stimulated with 14 hours of artificial light per day at 7 weeks of age.

TABLE 1.—Composition of Experimental Diets.

Ingredients	Diet A %	B %	C %	D %
Corn	52.55	49.30	51.25	48.00
Soybean meal, 44 %	26.06	26.68	26.31	26.93
Dehydrated alfalfa meal	3.00	3.00	3.00	3.00
Dried whey	2.00	2.00	2.00	2.00
Dried fish solubles	2.00	2.00	2.00	2.00
Distillers dried grains and solubles	2.00	2.00	2.00	2.00
Premix*	2.25	2.25	2.25	2.25
Trace mineralized salt†	0.40	0.40	0.40	0.40
Animal vegetable fat	3.54	4.74	4.02	5.22
Dicalcium phosphate (21.5 % Ca, 18.7 % P)	0.68	0.69	2.35	2.36
Limestone	5.52	6.94	4.42	5.84
Calculated composition				
Protein, %	19.00	19.00	19.00	19.00
Metabolizable energy, kcal/kg.	2860	2860	2860	2860
Methionine, %	0.38	0.38	0.38	0.38
Methionine + cystine, %	0.68	0.68	0.68	0.68
Lysine, %	0.99	1.00	0.99	1.01
Calcium, %	2.25	2.75	2.25	2.75
Available phosphorus, %	0.30	0.30	0.60	0.60

*Provides the following (per kg. diet): vitamin A, 8750 I.U.; vitamin D_3, 3750 I.U.; vitamin E (DL-α-tocopheryl acetate), 60 I.U.; menadione sodium bisulfite, 1 mg.; riboflavin, 3.6 mg.; niacin, 75 mg.; calcium pantothenate, 15 mg.; folacin, 0.8 mg.; biotin, 0.13 mg.; ethoxyquin, 125 mg.; selenium, 0.2 mg.; DL-methionine, 0.5 g.; choline chloride, 83 mg.

†Provides the following (per kg. diet): iodized sodium chloride, 3.75 g.; manganous oxide, 73 mg.; zinc oxide, 100 mg.

TABLE 2.—Effects of Dietary Calcium and Phosphorus on Performance of Japanese Quail Laying Hens.

Diet			Specific Gravity		Egg Weight (g.)		
Percent Ca	Percent Available P	19-Week Egg Production Percent	Day of Production 31-38	Day of Production 71-75	Day of Production 31-38	Day of Production 71-75	Feed Consumption (g./hen/day)
2.25	0.30	77.87	1.0660*	1.0685	9.90	10.39	22.7†
2.75	0.30	80.22	1.0705	1.0698	10.23	10.35	24.3
2.25	0.60	83.40	1.0690	1.0688	10.00	10.26	24.1
2.75	0.60	78.90	1.0702	1.0654	10.35	10.15	26.1
Pooled SEM‡		2.84	0.0012	0.0021	0.22	0.14	0.5

*Significant effect due to Ca ($P<0.05$).
†Significant effect due to Ca, P, and Ca x P ($P<0.005$).
‡Pooled standard error of the mean.

At the same time they were given the four experimental diets. Feed and water were supplied *ad libitum*. Each experimental diet was fed to four groups of six birds (24 quail per treatment). The collection period used for calculating egg production began 2 weeks after the hens received stimulatory lighting at which time the first eggs were laid.

Records were kept of egg production, feed consumption, body weight, egg weight, and egg specific gravity. Egg specific gravity was determined by weighing eggs in air and in water. All eggs of each replicate group of six hens collected during a given interval were weighed together.

RESULTS AND DISCUSSION

The effects of the two levels of calcium and phosphorus on egg production, specific gravity, egg weight, and feed consumption are shown in Table 2. During the 19-week collection period, there was no significant effect of dietary treatment on percent egg production. However, hens fed a diet containing 2.25% calcium and 0.6% available phosphorus had the highest egg production. After about 1 month of production, the hens fed the higher level of calcium had significantly higher egg specific gravities than those fed the lower levels of calcium. However, when the specific gravity of eggs collected from days 71 to 75 was determined, there was no significant dietary effect nor was there any significant dietary effect on average egg weight for either of the two collection periods.

Increasing both the level of phosphorus and calcium had a significant effect on average feed consumption (Table 2). Hens fed the low calcium-low phosphorus diet had the lowest feed consumption. Elevating either calcium or phosphorus led to approximately equal increases in feed consumption, while increasing both calcium and phosphorus led to an even higher average daily feed consumption.

There was no significant effect of diet on body weight changes. The hens gained approximately 40 grams during the 19-week production period. Three of the four birds which died during the experiment were fed the 2.25% calcium-0.3% phosphorus diet, while the other bird was fed the 2.75% calcium-0.3% phosphorus diet. No mortality was recorded for groups fed 0.6% phosphorus at either calcium level.

The results of this experiment indicate no detrimental effect due to lowering dietary available phosphorus from 0.6% to 0.3% of the diet. In addition, a level of 2.25% dietary calcium appears to be adequate for laying Japanese quail hens.

SUMMARY

The effect of two levels of dietary available phosphorus (0.3% and 0.6%) each fed at two levels of calcium (2.25% and 2.75%) on the performance of Japanese quail laying hens was studied. The dietary treatments did not significantly affect egg production, egg weight, or body weight. Increasing dietary calcium significantly increased egg specific gravity during one of two collection periods. Average daily feed intake was significantly increased by raising the levels of dietary calcium or phosphorus, or both.

LITERATURE CITED

1. National Research Council, Subcommittee on Poultry Nutrition. 1971. Nutrient Requirements of Domestic Animals. No. 1. Nutrient Requirements of Poultry. 6th revised ed. National Academy of Sciences, Washington, D. C.
2. Scott, M. L., A. Antillon, and P. A. Mullenhoff. 1975. The Effect of Levels of Calcium, Phosphorus and Vitamin D on Bone Development and Egg Shell Quality in Modern Laying Hens. Proc., Cornell Nutr. Conf., pp. 77-80.
3. Waldroup, P. W., J. F. Maxey, and L. W. Luther. 1974. Studies on the Calcium and Phosphorus Requirements of Caged Turkey Breeder Hens. Poultry Sci., 53: 886-888.

Effects of Selenium and Vitamin E on Nutritional Muscular Dystrophy in Turkey Poults

AUSTIN H. CANTOR and PHILIP D. MOORHEAD[1]

INTRODUCTION

Nutritional muscular dystrophy in turkeys was described by Jungherr and Pappenheimer (2). This was observed when they fed turkeys a semi-purified diet similar to one previously used to produce encephalomalacia in chicks. The condition was histologically characterized by hyaline necrosis of the smooth muscle fibers, a secondary inflammatory reaction, later disappearance of the fibers, and replacement fibrosis of the smooth muscle of the gizzard wall of the poults.

Walter and Jensen (11) studied the effects of vitamin E, selenium, ethoxyquin, and sulfur amino acids on the incidence of skeletal and gizzard muscular dystrophy in Broad Breasted Bronze turkey poults. Gizzard myopathy was the most striking symptom of selenium-vitamin E deficiency. A low incidence of skeletal muscular dystrophy was reported and there was little evidence of exudative diathesis. Ethoxyquin at 0.025% of the diet, selenium at 0.01 ppm or 0.1 ppm, cystine at 0.05%, or methionine at 0.4% did not prevent nutritional muscular dystrophy. Partial protection was obtained with 0.3% ethoxyquin, and complete protection was provided by 1.0 ppm selenium or 20 I.U. of vitamin E per kg. diet. Only 0.1 ppm selenium was required to prevent the anemia and reduced albumin:globulin ratios observed in poults fed the basal diets.

In further studies (12), Walter and Jensen showed that supplemental methionine accentuated the anemia in poults fed the basal diet and increased the selenium requirement for growth. In addition, the activity of the enzyme glutamic-oxaloacetic transaminase in serum appeared to be closely related to the incidence of muscular dystrophy. Low levels of selenium and vitamin E were shown to have an additive effect on prevention of muscular dystrophy.

Complete prevention of gizzard myopathy was obtained with 0.2 ppm selenium as sodium selenite when added to a low selenium practical starter diet containing 0.08 ppm naturally occurring selenium (8). However, only 0.05 ppm selenium was required to obtain maximum growth. In the presence of 11 I.U. vitamin E per kg. diet or 0.1% methionine, only 0.1 ppm selenium was needed to prevent gizzard myopathy.

Thompson and Scott (9, 10) showed that feeding chicks a crystalline amino acid diet extremely deficient in selenium resulted in pancreatic fibrosis. This condition was characterized by decreased absorption of fats and fat-soluble substances, including vitamin E, causing the selenium deficient animals to have a lower concentration of plasma tocopherols. This condition has not been demonstrated in turkeys.

Studies by Rotruck *et al.* (7) demonstrated that selenium was an integral part of the enzyme glutathione peroxidase. Following this report, Noguchi *et al.* (5) demonstrated a relationship between the prevention of exudative diathesis in chicks and the activity of plasma glutathione peroxidase. The biological activity of selenium from sodium selenite was found to be greater than that of seleno-methionine for prevention of exudative diathesis (1). The biological activity of selenium of these compounds was highly correlated with the activity of plasma glutathione peroxidase.

The turkey differs from the chicken with respect to both nutritional requirements as well as deficiency symptoms of selenium and vitamin E. Furthermore, relatively little has been done regarding the biochemical function of selenium in the turkey. Therefore, it was of interest to further examine the role of selenium and vitamin E with respect to nutritional muscular dystrophy in the turkey.

MATERIALS AND METHODS

The poults used in this experiment were from two genetic lines of large white breeder hens fed diets low in selenium and vitamin E starting approximately 8 weeks before beginning egg production. Poults were housed in battery brooders with raised wire floors. Feed and water were supplied *ad libitum*. Duplicate lots of five newly hatched poults (straight run) were assigned to each dietary treatment. The low selenium-low vitamin E basal diet contained corn, soybean meal, and torula yeast as the principal ingredients (Table 1). The basal diet was fed alone or supplemented with 0.15 ppm selenium as sodium selenite, with 50 I.U. vitamin E (DL-alpha-tocopheryl acetate) per kg. diet, or both in a factorial arrangement.

[1]Assistant Professor, Dept. of Poultry Science, and Associate Professor, Dept. of Veterinary Science, respectively, Ohio Agricultural Research and Development Center.

TABLE 1.—Selenium and Vitamin E-Deficient Turkey Starter Diet.

Ingredient	Percent
Corn	41.2
Soybean meal (44%)	28.0
Torula yeast	25.0
Dicalcium phosphate (feed grade)	1.9
Limestone (feed grade)	1.7
Vitamin mix*	0.5
Trace mineral salt†	0.4
Choline chloride, 50%	0.2
DL-methionine (feed grade)	0.1
Animal-vegetable fat	1.0
	100.00

*Supplied the following (per kg. diet): retinyl palmitate, 9990 I.U.; vitamin D_3, 4000 I.U.; menadione sodium bisulfite, 3 mg.; thiamine hydrochloride, 4 mg.; riboflavin, 6 mg.; D-calcium pantothenate, 20 mg.; niacin, 80 mg.; pyridoxine hydrochloride, 4 mg.; biotin, 0.3 mg.; folacin, 1 mg.; vitamin B_{12}, 15 μg; and butylated hydroxy toluene, 125 mg.

†Supplied the following (per kg. diet): iodized sodium chloride, 3.75 g.; manganous oxide, 73 mg.; and zinc oxide, 100 mg.

At the end of the 4-week feeding trial, blood samples were taken by cardiac puncture using heparinized syringes for future laboratory analyses. All poults were then sacrificed and the incidence of gizzard myopathy was determined by gross visual examination.

Individual blood samples were used for determining percent hematocrit and plasma glutamic-oxaloacetic transaminase (PGOT). PGOT was measured using a single reagent clinical procedure (Technical Bulletin 55-UV, Sigma Chemical Co.). The remaining laboratory analyses were performed on blood plasma pooled from all poults within a replicate pen. Plasma protein was determined according to the method of Lowry *et al.* (3). Glutathione peroxidase was determined according to Noguchi *et al.* (5). Selenium was determined according to the method of Olson (6), while the procedure of Martinek (4) was used for determining plasma tocopherols.

RESULTS AND DISCUSSION

The only symptom seen upon gross visual examination of the selenium-vitamin E deficient poults was gizzard myopathy. In most cases this appeared as white striations running through the red muscle of the gizzard, but gizzard lining was unaffected. Dystrophy of other muscles examined was not obvious, and exudative diathesis was not seen.

Both selenium and vitamin E completely prevented gizzard myopathy as determined by gross examination (Table 2). However, only selenium significantly improved body weight at 28 days of age.

No differences in percent hematocrit or plasma protein concentration were found among the various treatments (Table 2). Plasma selenium concentration was significantly increased by the addition of sodium selenite to the basal diet but was unaffected by dietary vitamin E. On the other hand, dietary vitamin E but not selenium significantly increased the concentration of plasma tocopherols. Thus, while both nutrients appeared to alleviate the deficiency symptoms, there was no interaction of these nutrients with respect to their concentrations in plasma.

Dietary selenium significantly increased glutathione peroxidase activity (Table 2). However, the addition of vitamin E to the diet did not have any effect on this enzyme. On the other hand, both dietary selenium and vitamin E significantly reduced PGOT compared to poults receiving the basal diet.

The relationship between plasma glutathione peroxidase specific activity and plasma selenium concentration was further examined. As shown in Table 3, glutathione peroxidase was highly correlated with plasma selenium concentration when the data from

TABLE 2.—Effects of Selenium and Vitamin E on Selenium and Vitamin E-Deficient Turkey Poults.

Diet	Body Wt. at 28 Days g.	Incidence of Gizzard Myopathy Percent	Hematocrit Percent	Plasma Se ppm	Plasma Tocopherols μg/ml	Plasma Glutathione Peroxidase Specific Activity Units/mg Protein	PGOT* Karmen Units/ml	Plasma Protein mg/ml
Basal	346	100	32.7	0.009	9	6.8	469	35.6
+ Selenium†	489	0	32.9	0.067	7	24.3	120	36.7
+ Vitamin E‡	398	0	32.3	0.010	55	4.5	107	35.6
+ Selenium + Vitamin E	435	0	32.2	0.065	65	22.0	120	36.1
Pooled SEM**	23		1.3	0.004	7	1.4	37	1.0
Significant Treatment Effects	Se			Se	Vit. E	Se	Se Vit. E Se X Vit. E	

*Plasma glutamic-oxaloacetic transaminase.
†0.15 ppm selenium as sodium selenite.
‡50 I.U. vitamin E/kg. diet as DL-α-tocopheryl acetate.
**Pooled standard error of the mean.

TABLE 3.—Relationship of Glutathione Peroxidase Specific Activity and the Concentration of Selenium in the Plasma of Turkey Poults.

Y = Plasma Glutathione Peroxidase Specific Activity
X = Plasma Selenium Concentration

Selenium in Turkey Diet	Regression Equation	r	Level of Significance
±	Y = 304 X + 2.71	+ 0.986	P<.01
—	Y = 1.165 X + 16.9	— 0.579	N.S.*
+	Y = 355 X — 0.952	+ 0.959	P<.01

*Not significant.

either all turkeys or just those supplemented with selenium were used. When data from turkeys fed the basal diet alone or with vitamin E but with no selenium were used, a non-significant relationship was observed. A possible explanation for this last observation is that not all the naturally occurring selenium in the basal diet was biologically available for this enzyme activity.

SUMMARY

Gizzard myopathy was prevented in selenium-vitamin E deficient poults with either selenium or vitamin E. However, only selenium improved body weight gains. Plasma selenium was increased by dietary selenium but was unaffected by dietary vitamin E. Plasma tocopherols were increased by the addition of vitamin E to the diet but not by dietary selenium. Dietary selenium also increased the activity of plasma glutathione peroxidase. Both selenium and vitamin E decreased plasma glutamic oxaloacetic transaminase activity.

LITERATURE CITED

1. Cantor, A. H., M. L. Scott, and T. Noguchi. 1975. Biological Availability of Selenium in Feedstuffs and Selenium Compounds for Prevention of Exudative Diathesis in Chicks. J. Nutr., 105: 96-105.
2. Jungherr, E. and A. M. Pappenheimer. 1937. Nutritional Myopathy of the Gizzard in Turkeys. Proc., Soc. Exp. Biol. Med., 75: 520-526.
3. Lowry, O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall. 1951. Protein Measurement with the Folin Phenol Reagent. J. Biol. Chem., 193: 265-275.
4. Martinek, R. G. 1964. Method for the Determination of Vitamin E (Total Tocopherols) in Serum. Clin. Chem., 10: 1078-1086.
5. Noguchi, T., A. H. Cantor, and M. L. Scott. 1973. Mode of Action of Selenium and Vitamin E in Prevention of Exudative Diathesis in Chicks. J. Nutr., 103: 1502-1511.
6. Olson, O. E. 1969. Fluorometric Analysis of Selenium in Plants. J. Assoc. Official Anal. Chem., 52: 627-634.
7. Rotruck, J. T., A. L. Pope, H. E. Ganther, A. B. Swanson, D. G. Hafeman, and W. G. Hoekstra. 1973. Selenium: Biochemical Role as a Component of Glutathione Peroxidase. Science, 179: 588-590.
8. Scott, M. L., G. Olson, L. Krook, and W. R. Brown. 1967. Selenium-responsive Myopathies of Myocardium and Smooth Muscle in the Young Poult. J. Nutr., 91: 573-583.
9. Thompson, J. N. and M. L. Scott. 1969. Role of Selenium in the Nutrition of the Chick. J. Nutr., 97: 335-342.
10. Thompson, J. N. and M. L. Scott. 1970. Impaired Lipid and Vitamin E Absorption Related to Atrophy of the Pancreas in Selenium-deficient Chicks. J. Nutr., 100: 797-809.
11. Walter, E. D. and L. S. Jensen. 1963. Effectiveness of Selenium and Noneffectiveness of Sulfur Amino Acids in Preventing Muscular Dystrophy in the Turkey Poult. J. Nutr., 80: 327-331.
12. Walter, E. D. and L. S. Jensen. 1964. Serum Glutamic-Oxaloacetic Transaminase Levels, Muscular Dystrophy and Certain Hematological Measurements in Chicks and Poults as Influenced by Vitamin E, Selenium and Methionine. Poultry Sci., 43: 919-926.

The State Is the Campus for Agricultural Research and Development

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

Research is conducted by 15 departments on more than 7000 acres at Center headquarters in Wooster, seven branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Agricultural Research Service, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres